STUDY OF MECANICAL AND TECHNOLOGICAL ASPECTS OF METAL - POLYMER – SOFT METAL - CERAMICS COATINGS

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A number of composite sliding bearings is have to know contain steel base, on which one a layer of soft material like aluminum is formed, and a top layer of ceramics impregnated with a solid lubricant is formed on the soft material.

One of disadvantage of this type of bearing is low adhesion between adjacent layers due to an interlayer of soft metal (for example, aluminum or its alloys) is formed with an casting or welding method on a very smooth steel base. By its activity even rather low-level shearing stresses can result in to shift of a layer of soft metal with a cracks initiation and microflaws propagation. As a subsequent result all composite layer is shattered. Besides the bearing has rather low damping capacity because of it contains layers from rigid material with high modulus of elasticity having restricted abilities to damp oscillations and chattering. manufacturing process of the bearing does not always allow to form thin interlayer up to 40-200 microns with high vibration resistance and damping properties. The above-mentioned disadvantages reduce strength and vibro-acoustic characteristic of such bearings, and degrade its operational properties.

To improve operating properties and decrease disadvantages our team design and tests new composite sliding bearing and manufacturing technology. the bearing sequentially arranged main layers are steel base, polymer layer, aluminum or its alloy layer and oxide ceramic layer. The polymer may be selected from the group included a polyamide, polyvinylchloride, polyethylene, polyethyleneterephthalate or others. Along with it the steel base has ledges and cavities arranged in the quincunx order. the altitude of the profile exceeds which one thickness of a polymer layer in 1,2 … 1,8 times. the layer of aluminum or its alloy has complementary surface and thickness selected from the following ratio (1):

$$\delta A = (0{,}6 \div 0{,}8)\cdot К\cdot(Суд/Ea)1/3 \qquad (1)$$

Where δA is the minimum bed depth of aluminum or its alloy. К is a factor depended from the form of a working surface of a bearing. for example, a cylindrical self-contained sliding bearing has К equal to R, where R is the radius of the working surface of the cylindrical sliding bearing. Cyd is the specific contact rigidity of a polymer. Ea is the modulus of elasticity of aluminum or its alloy. To form the layers the method of the thermal flame spraying was used. this choice is actual because of only application of the process it is possible to reshape coating of fusible materials by thickness from two tens micron up to several millimeters. Along with it the Used process does not superheat the surface and material of the substrate repeating its profile. The process allows to make it with the greatest efficiency on surfaces of the different configurations.

The thickness of the polymer layer depends on technological ways of deposition of the subsequent layer from aluminum or its alloys. The more size of fragments of formed aluminum and its temperature, the large thickness should have a polymer layer to not be shattered from thermal effect of the maiden fragments dropping on its surface. This semiempirical relation was developed and was investigated with a number of experimental researches conducted in our institute.

Manufacturing technology of the composite sliding bearing includes formation on the steel base the polymer layer, then the layer of aluminum or its alloys and then top oxide ceramic layer. Formation of the polymer layer and aluminum layer performs by the thermal flame spraying method. Thickness of the polymer layer is calculated with the ratio (2):

$$\delta = N\sqrt{a\cdot\tau\cdot\ln[K\frac{D^3\rho_1}{c\rho}(c_1T+\lambda)]} \quad (2)$$

Where ♎ is the bed depth. D is the diameter of a drip of the sprayed aluminum or his(its) alloy. ♦ is the time elapsed from a moment of contact of a drop with temperature T sprayed aluminum with polymer layer up to propagation of a heat deep into it. This time ♦ is calculated with the ratio (3):

♦ = (T·c1·r1·V) / (a ·S·To) (3)

Where V is the volume and S is the area of surface of the fragment. a is the factor of heat rejection. To is the temperature of the cooled down fragment. N is an empirical factor equal to 2,2 … 2,6. ● is the specific melting heat of aluminum or its alloy. ❒1 is the specific mass of aluminum or its alloy. c1 is the specific heat of aluminum or its alloy. a is the thermal diffusivity of the polymer layer. c is the specific heat of the polymer layer. ❒ is the specific mass of the polymer layer. К is an empirical factor equal to 1,15·1011.

Researches of shear strength in a circumferential direction and vibration resistance tests of the bearing have shown high reliability, wear and vibration resistance in a complex exceeding the same properties of known analogs.

It seems that application of this engineering solution allows to create high-performance sliding bearings for different devices worked in conditions of friction with lubricants or greases.